

Cadmium Oxide Nano Particles by Sol-Gel and Vapour-Liquid-Solid Methods

S. SAKTHIVEL* and D. MANGALARAJ¹

*PG and Research Department of Physics, Rajah Serfoji Govt. College,
Thanjavur-613005, Tamilnadu, India

¹ Department of Nano Physics, Bharathiar University,
Coimbatore-641 046, Tamilnadu, India

ABSTRACT

Cadmium Oxide (CdO) Nano particles were prepared by simple spray pyrolysis technique. For calculating particle size, d-spacing value and structure of the CdO nanoparticle X-ray diffractogram spectrum were taken. Presence of cadmium and oxygen verified by FTIR spectrum. Size of the CdO nano particles were detected by Scanning Electron Microscope picture.

Key words: CdO, Nano particle, Spray pyrolysis, SEM.

INTRODUCTION

In recent years conducting oxides have great attention because of its gas sensing properties under atmospheric conditions. Nano particle report on Cadmium Oxide (CdO) are very limited among oxides such as tin, zinc and cadmium. Imagine being able to conduct electricity through particles that are 2000 times thinner than a stand of hair. Nano technology is providing the means to create such “Nano particles”, which are essentially shrunken down versions of modern day particles and are made of various metals. Currently, Nano particles are in the research and development phase; however, progress is showing a bright future for the particles especially for computing devices and sensor applications. CdO is prepared commercially

by oxidizing Cadmium vapor in air.¹³ CdO is used in Cadmium plating baths, electrodes for storage batteries, Cadmium salts, catalyst ceramic glazes, phosphors, and nematouide. Major uses for Cadmium Oxide is as an ingredient for electroplating baths and pigments.¹⁻³

CdO is a basic Oxide and is thus attacked by aqueous acids to give solutions of $[\text{Cd}(\text{H}_2\text{O})_6]^{2+}$. Upon treatment with strong alkaline solutions, $[\text{Cd}(\text{OH})_4]^{2-}$ forms. A thin coat of Cadmium Oxide forms on the surface of Cadmium in moist air at room temperature. Cadmium will Oxide at room temperature to form CdO. Cadmium vapor and steam will form CdO and Hydrogen in a reversible reaction.⁴ Nano particles are very useful in transistors, solar cells LED's and diode lasers. Nano particles also useful as agents of medical imaging. The main

advantages in using Nano particles is that because of the high level of control possible over the size of the crystal produced, it is possible to have very precise control over the conductive properties of the material. Self-assembled Nano particles typically between 5 and 50nm in size.

Nano particles have a sharper density of states, so they have superior transport and optical properties, and are being researched for use in amplifiers, and biological sensors. Nano particles are one of the most hopeful candidates for solid-state Nano computation. By applying small voltages to the leads, one can control the flow of electrons through the Nano dot and there by make precise measurement of the spin and other properties.

EXPERIMENTS

Cadmium Oxide Nano particles prepared by dip coating spray pyrolysis. A large number of metallic salt solutions when Sprayed onto a hot substrate decompose to yield Oxide film. The chemical solution into Spray of fine droplets is effected by the Spray nozzle with the help of a filtered carrier gas which (oxide films) or may not be involved in the pyrolytic reaction.

The carrier gas and the solution are fed into the Spray nozzle at predetermined and constant pressure and flow rates. The substrate temperature is maintained with the help of a feedback circuit which control primary and an auxiliary heater-power supply. The geometry of the gas and the liquid nozzles strongly determines the Spray pattern. Size distribution of droplets and Spray rate which in turn determines growth kinetics and hence the equality of films and nano particle obtained.

The given CdCl_2 (0.1g) is dissolved using water (62.5ml) and it is taken in a pipette. The end of the pipette is connected with a rubber tube extended from a compressor. The solution and compressed air released at same point. So we get fine droplets the same deposited on the substrate which is kept on the hot furnace, and it is for away 20 cm from substrate. The substrate temperature is 175°C .

Dip coating refers to the immersing of a substrate into a beaker containing coating material in the form of transparent liquid. Removing the piece from the beaker, and allowing it to dry in the open atmosphere. It is a popular way of creating thin film coated materials along with the spin coating procedure.

Nano particles prepared by spray pyrolysis analysed by X – Ray diffraction. (XRD PAN analytical-Make, X Per PRO-Model). From the geometrical considerations the basic Bragg equation is formed as $2d\sin\theta = n\lambda$, where d is the inter plan distance (or lattice constant), is the wavelength of the characteristic X – rays and 2θ is the angle between the diffracted beam and the transmitted beam and n is the order of the scalded beam. This famous Bragg's law provides the basic platform for the XRD methods. The effect of line broadening is primarily due to the micro – residual stress and particle size. In case of negligible micro – residual stress the particle or crystalline size (D) is determined from.

$$D = 0.9 \lambda / \beta \cos\theta \quad (2.1)$$

Where, β is the broadening of the line measured at half its minimum integrity in lattice.

Fourier transform infrared spectroscopy (FTIR)-is a technique which is used to

obtain an infrared spectrum of cadmium oxide nano particles [thermo electron corporation-make, NEXUS 670-model]

FTIR spectrometer collects spectral data in a wide spectral range. From these spectroscopy presence of Cd and O were analysed in the CdO nano particles.

The morphology of the nano-particles was examined by scanning electron microscope [HITACHI-MAKE, S-3000H, SEM-MODEL]. The applied voltage for getting secondary electron is 20KV and working distance of 17.4mm and magnification power is X25K and scale used for length from 0 μ m to 20 μ m.

RESULT AND DISCUSSION

Dip coating and Spray pyrolysed techniques were used to synthesis nano-particles. Fabricated nanoparticles are employed for SEM analysis and its results were discussed. The SEM image of Nano-particles in a particular position of the sample are taken at various magnification that is 20 μ m, 10 μ m and 5 μ m.

The SEM image figure 3.1 reveals that product contains Cadmium Oxide Nano particles obtained in three different regions shown in figure 3.1. The middle region contains nine particles its diameters/size are 50nm. In the first region obtained the SEM figure contains 4 particles and its diameter/size 45nm. Similarly in the right side middle contains 5 Nano particles of diameter/size of 65 nm. These three regions are indicated in the SEM photograph. In SEM figure 3.2 it is found that there will be a circle of Nano particles on the left side of the photograph, here also two regions are obtained one is deep region and rest is bright region. In the SEM photograph figure 3.3 shows that there will

be a Nano particles diameter/size less than 10nms are present along with the random size Cadmium crystals.

Fourth SEM photograph clearly shows the combinations of Nano particles and random size Cadmium crystal. This is indicated in bright in spot of Cadmium crystals and smoke gray CdO Nano particles. This shows in the figure 3.4. From the above experiment it is concluded that even though the Nano particles nominal particle size is ranging from 2 to 8nm such a fine Nano particles also available in the above four SEM photographs But in our case the size of Nano particles obtained in the ranging from 5nm to 65nm range.

The Spray pyrolysed CdO Nano particles have been structurally characterized by X ray diffraction employing copper K-Alpha and K-beta radiation. A typical XRD pattern of Cadmium Oxide Nano particles are shown in figure 3.5.

It can be seen that the Nano particles displays the structure with high crystallinity Compared with the standard diffraction pattern of Cadmium Oxide.

From the XRD spectrum it is seen that the 2θ value at 32.657, the peak height is 52.92 and its full width half maximum value is 0.9792 and corresponding d spacing value is 2.74.Å⁰. The rest of the peak shows the polycrystalline nature of the Nano particles (Table 3.1).

Spray pyrolysed CdO nanoparticles were characterized by FTIR and its corresponding spectrum is shown in figure 3.6.

The sharp peak at 1270 cm⁻¹ and comparatively two small peaks corresponds in the presence of Cadmium and oxygen in the sample. In the FTIR spectrum the strong absorption in the range of 1270 to 1641 cm⁻¹,

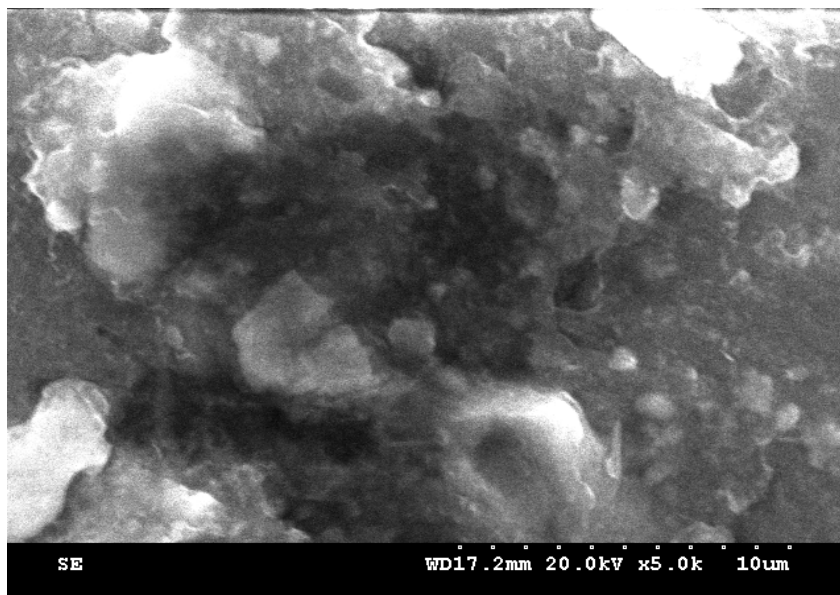


Fig.3.1 SEM Pattern of CdO Nano particles (10 micrometer)

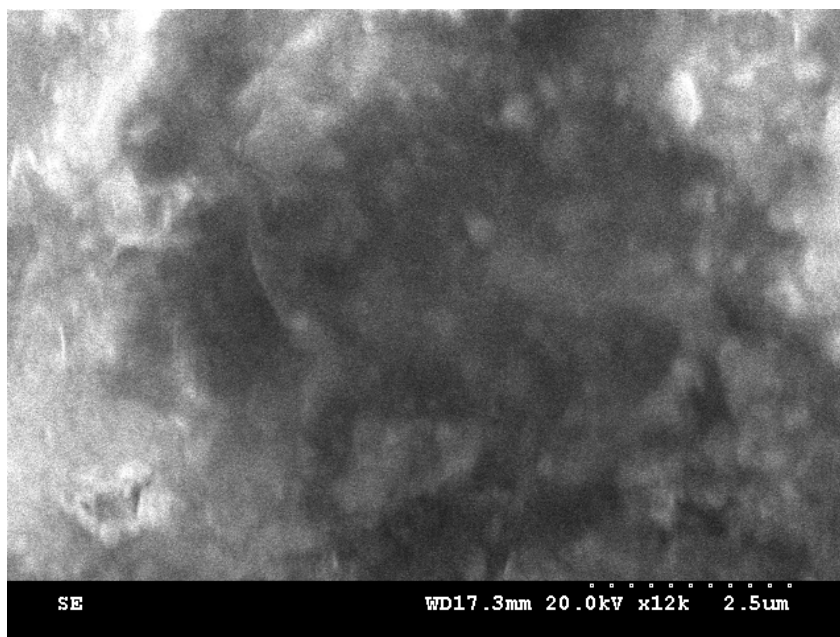


Fig.3.2 SEM Pattern of CdO Nano particles (2.5 micrometer)

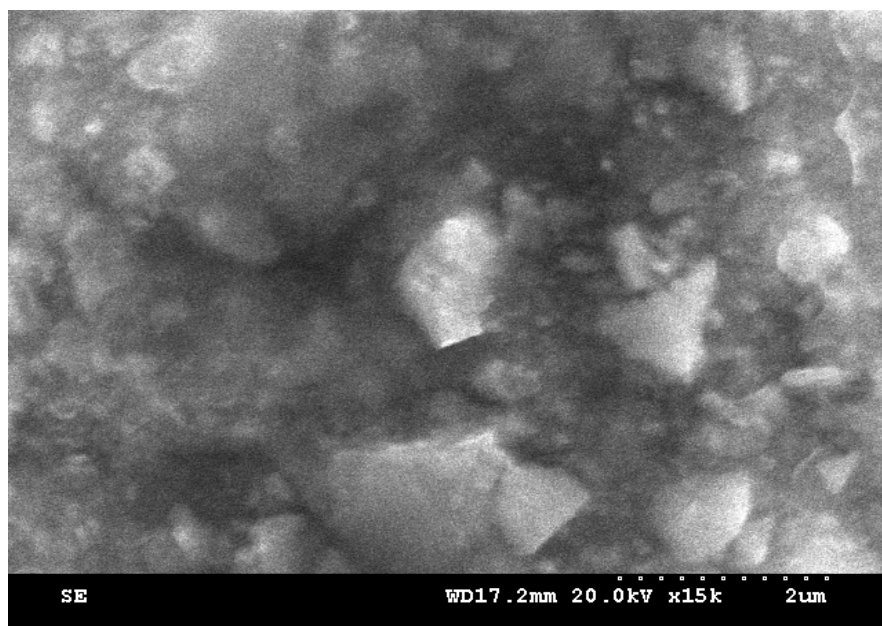


Fig.3.3. SEM Pattern of CdO Nano particles (2 micrometer)

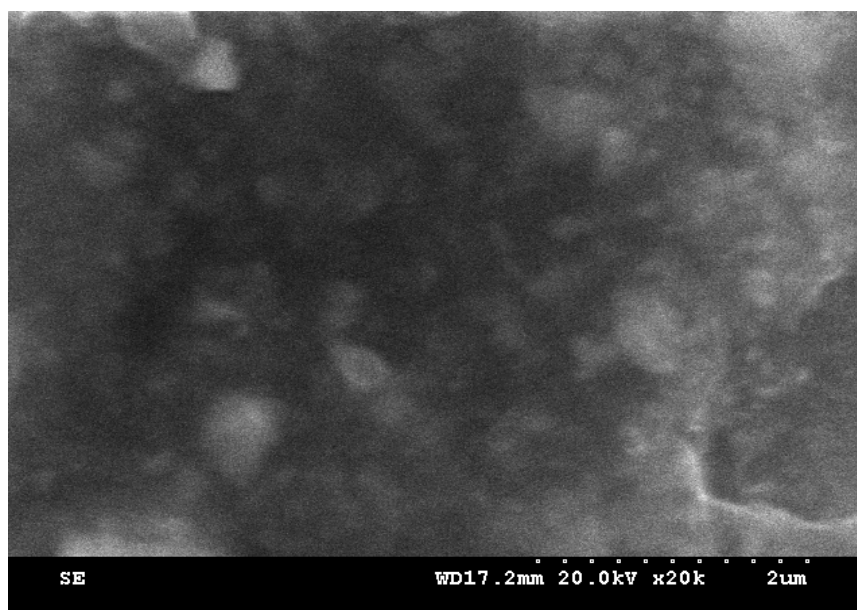


Fig.3.4. SEM Pattern of CdO Nano particles (2 micrometer)

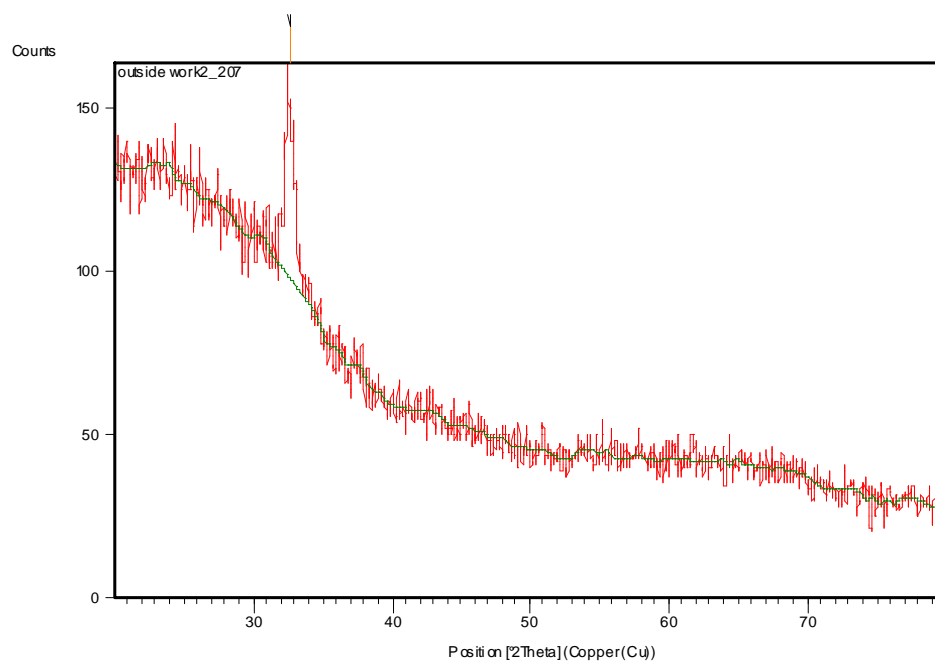


Fig.3.5. XRD Pattern of CdO Nano particles

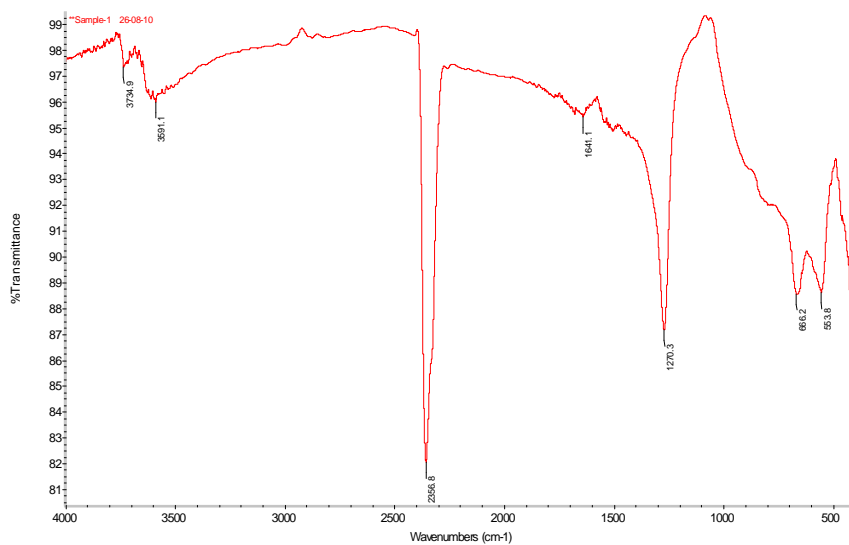


Fig.3.6.FTIR Spectrum of CdO nano particles

Table 1
d-Spacing values of CdO Nano particles

| Pos. [$^{\circ}$ 2Th.] | Height [cts] | FWHM [$^{\circ}$ 2Th.] | d-spacing [\AA] | Rel. Int. [%] |
|-------------------------|--------------|-------------------------|----------------------------|---------------|
| 32.6575 | 52.92 | 0.9792 | 2.73984 | 100.00 |

and the other couple of peaks in the range of 553 and 666. The weak absorption at 1641 is also found in the FTIR spectrum. The above Cadmium reacting with oxygen in the air during the time of preparing CdO nanoparticle by Spray Pyrolysis.

From the FTIR spectrum it is conformed that presence of Cd and oxygen in the range between 1641 to 1270 cm^{-1} respectively.

CONCLUSIONS

Nano particles have been found useful due to sensing capability for various particular applications in the field such as Optoelectronics and Medicine.

From the XRD it is seen that CdO Nano particles are in crystal structure. The diffraction peaks indicates that resulting products have CdO phase having plane 100 at angle $2\theta = 32.657^{\circ}$. The FTIR spectrum identified the presence of Cadmium and oxygen very strongly. The SEM picture shows the presence of Nano particles in three different regions with three different Nano particles size. Nano particles are

identified in three different regions, these regions are due to the angle of spray and solution concentration and spray time. Very limited reports are available on cadmium oxide nanoparticles.

Even the size of the CdO Nano particles some what greater than 10 nm it possible to fabricate a Nano particles of size less than 10 nm by Spray pyrolysis technique.

REFERENCES

1. Karunakaran, C; Dhanalakshmi, R. Selectivity in photo catalysis by particulate semiconductors". *Central European Journal of Chemistry* 7(1): 134. (2009)
2. Lewis, Richard. J., Sr., Hawley's condensed chemical dictionary, 13th ed, p.189 (1997).
3. Clifford A.Hampel and Gessner G. Hawley, the encyclopedia of chemistry, 3rd ed., p.169 (1973).
4. Clifford A. Hampel, Rare metals hand book, p.87-103 (1954).